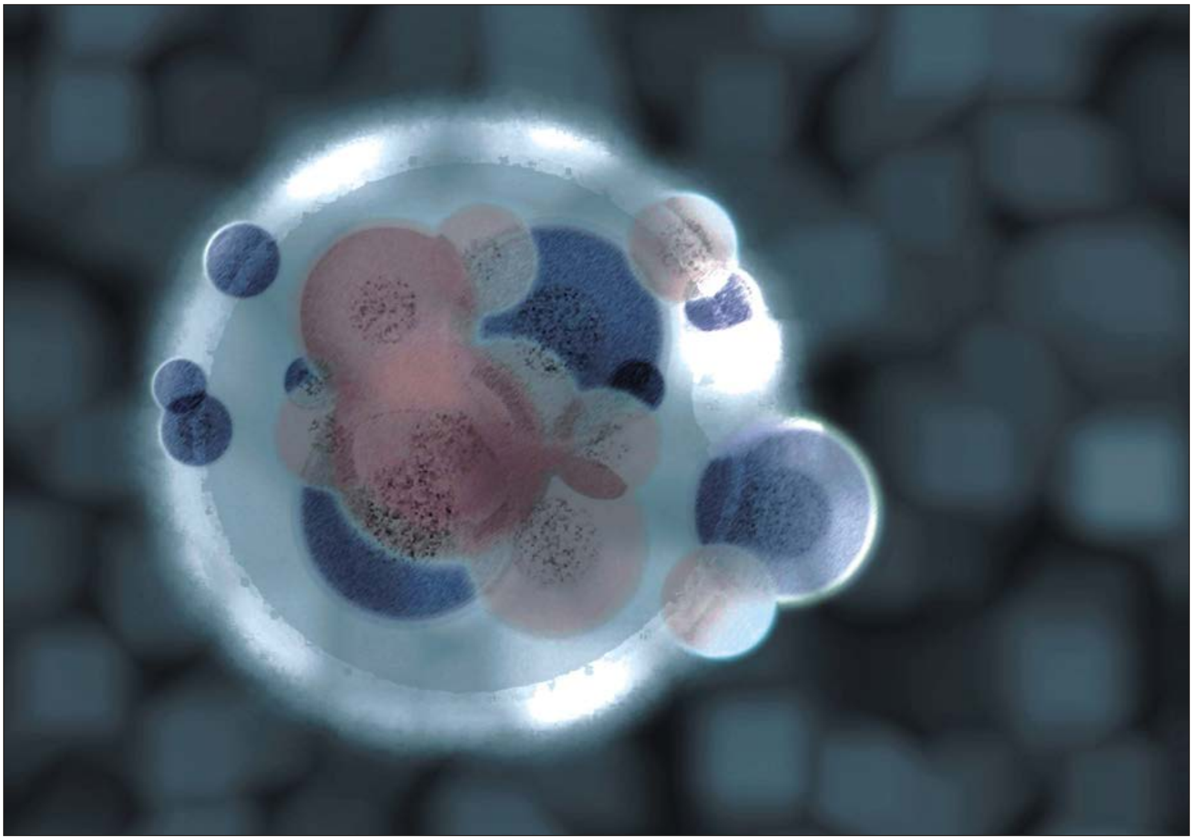

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Nodulation, Chlorophyll Content and Nitrogen Yield of Two Woody Legumes at a Rainforest Location in Nigeria

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Abstract: Field studies were conducted at Ile-Ife between 2000 and 2002 to compare the nodulation, chlorophyll content and nitrogen accumulation of *Leucaena leucocephala* (Lam) de Wit cv. 28 and *Gliricidia sepium* (Jacq.) Walp cv. ILG50 at the early stages of growth (2-16 Months after Planting) (MAP) to evaluate the two species under no external input system routinely practiced by farmers. A Randomized Complete Block Design in three replications with species as the single factor was used. The number of nodules produced by *G. sepium* (96.0/plant) was higher than in *L. leucocephala* (44.0/plant). At 12 and 16 MAP, leaf total chlorophyll content of *G. sepium* was 6.12 $\mu M\ g^{-1}$ and significantly ($p<0.05$) higher than 4.12 $\mu M\ g^{-1}$ produced by *L. leucocephala*. However, chlorophyll stability index of *L. leucocephala* was greater significantly ($p<0.05$) than that of *G. sepium* (94.5 vs 69.7%). At final sampling (16 MAP), *G. sepium* partitioned 48.3 and 51.7% of its total nitrogen content to below ground and above ground parts, respectively. In contrast, *L. leucocephala* partitioned 35.3 and 64.7% of its total nitrogen content into below ground and above ground parts respectively. Significantly ($p<0.05$) higher nitrogen accumulation occurred in *G. sepium* (54.20 kg/plant) than in *L. leucocephala* (42.80 kg/plant) at 16 MAP. It is concluded from the study that productivity of *G. sepium* as hedge species is higher than *L. leucocephala* in terms of nodulation, chlorophyll content and nitrogen yield under no-external input field conditions.

Key words: Chlorophyll, *G. sepium*, *L. leucocephala*, nodulation index

INTRODUCTION

Woody legumes' growth is soil, relief and ecology specific, hence several leguminous trees were tested for suitability for alley farming in the tropics (Kang *et al*., 1984). Out of those evaluated, *Leucaena leucocephala* (Lam) de Wit and *Gliricidia sepium* (Jacq) Walp are among the best performing woody legumes in the humid and sub-humid tropics (Oikeh, 1999). The most important benefit derivable from using the two woody legumes in alley cropping is biological nitrogen fixation through nodulation. Both species nodulated easily with native rhizobia (Dutt and Patharia, 1986; Mulongoy and Owoaje, 1992). Ezenwa and Atta-krah (1992) reported that *G. sepium* had higher number of nodules and fresh weight of nodules per plant than *L. leucocephala*. They observed further that nodules were formed at 12 weeks after planting in *L. leucocephala* whereas nodules were formed at 8 weeks after planting in *G. sepium*. Britwum (1988) reported that *G. sepium* and *L. leucocephala* yielded 376 and 339 kg N/ha/year, respectively. At 6 months after planting, *L. leucocephala* has higher shoot nitrogen content (995 mg/plant) than *G. sepium* (700 mg/plant) according to Sanginga *et al*. (1990). Mulongoy and Owoaje (1992) however reported higher shoot nitrogen content of *G. sepium* (97 mg/plant) than in *L. leucocephala* (50 mg/plant) at 6 months of age; nitrogen yield in both species have also been reported to increase steadily with age (Kadiata *et al*., 1996).

Chlorophyll content is an index of organic matter production and plant growth (Van de Mescht *et al*., 1999; Lahai *et al*., 2003). This is because increased photosynthesis has been linked to increased chlorophyll content in plants (Chowdhury and Kohri, 2003). As a result, chlorophyll content is a measurement of physiological activities in plants. Impairment of total chlorophyll, chlorophyll a and b in *Pennisetam typhoideum* confirmed the role of lead and mercury in porphyrin metabolism and pollutant effect in *Gliricidia sepium* (Prasad and Prasad, 1990; Salgare and Anis, 1992). Chlorophyll content of drought-tolerant potato cultivars were greater than non-tolerant cultivars (Van de Mescht *et al*., 1999). Similarly, as a result of strong correlation between root yield and chlorophyll concentration in cassava, Lahai *et al*. (2003) suggested that cassava cultivar with high leaf chlorophyll content would maintained high yield under stress condition. Furthermore, seasonal growth in trees and herbaceous

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plants is correlated to fluctuation in concentration of total chlorophyll, chlorophyll a and b (Chowdhury and Kohri, 2003). Chlorophyll stability index was used by Sivasubramaniam (1992) as a means of determining drought hardiness in *Acacia* species. In this trial, he found the chlorophyll stability index of *Acacia auriculiformis* A. Lunner Benth and *A. bowlii* (L.) Benth to be 96.26 and 66.48%, respectively. Chlorophyll content and chlorophyll stability index of *L. leucocephala* and *G. sepium* have not been monitored and compared in the literature as a measure of productivity potential of the trees.

The first indication of pitfall in alley cropping technology is non-reproducibility of positive results from research station experience on farmers' farm (Coe, 1994). Evidence from a long-term trial indicated that researchers have overestimated the capacity of the technology to increase crop yield due to experimental and interpretational problems (Ong, 1994). As a result, significant numbers of farmers who have earlier adopted the technology have abandoned it (Ong, 1994). Most of the evaluation studies that lead to suggestion of inclusion of the two species in alley cropping were short-term and greenhouse experiments. Besides, external inputs and seed treatment of the trees were features of most of the studies. These include phosphorus and nitrogen application and inoculation of seeds with rhizobium strains. Farmers do not incorporate all these practices. They practice no external input alley cropping. Thus a disparity exists between the conditions under which the trees were evaluated and what obtains in the farmers field. Mulongoy and Owoaje (1992) had earlier cautioned on extrapolation of greenhouse result to field conditions since greenhouse studies are hardly reproduced under field conduction. The objective of the study reported here was to compare the nodulation and nitrogen yield, chlorophyll content and stability index of *L. leucocephala* and *G. sepium* under no-external input field conditions.

MATERIALS AND METHODS

The study were conducted at the Teaching and Research farm of the Obafemi Awolowo University, Ile-Ife (07°28'N, 04°33'E), Nigeria between 2000 and 2002. Ile-Ife has a bimodial rainfall pattern with peaks in June and September and short break in August. The total annual rainfall for 2000, 2001 and 2002 were 1317.5, 1233.5 and 1011.7 mm^2, respectively. The mean monthly maximum and minimum temperatures for the period were presented in Table 1. Ile-Ife is 244 m above sea level.

Land preparation, experimental design and trees establishment: The experimental plot was cleared of secondary vegetation. The site has no history of tree legumes. The plot was then disc ploughed and harrowed with a disc plough and harrow respectively to get a well-pulverised seedbed prior to seed sowing. Soil samples were taken from surface soil (0-100 cm) for determination of soil chemical properties. The textural class of the soil was sandy loam at 0-15 cm depth. The chemical properties of the soil at the experimental site were presented in Table 2.

Table 1: Weather conditions at the experimental station from 2000 to 2002

	2000			2001			2002		
	Daily Temp. (°C)		Total rainfall	Daily Temp. (°C)		Total rainfall	Daily Temp. (°C)		Total rainfall
Month	Max.	Min.	(mm)	Max.	Min.	(mm)	Max.	Min.	(mm)
January	39.5	13.2	0	40.1	29.5	1.5	40.0	28.5	0.0
February	47.7	13.8	32.0	42.3	29.1	1.8	45.6	29.3	8.1
March	40.0	13.6	65.3	40.1	29.1	120.5	39.2	20.2	77.8
April	38.3	13.4	70.1	37.8	28.9	275.0	38.0	22.1	83.0
May	37.3	14.0	75.0	36.7	28.7	123.0	36.4	24.2	133.8
June	36.3	24.0	110.1	34.8	28.0	51.0	35.2	20.3	185.6
July	34.7	27.4	276.6	33.7	28.9	111.1	34.7	20.1	188.9
August	33.7	28.3	190.1	33.7	29.0	79.9	33.7	21.2	28.5
September	33.3	26.8	285.1	36.1	29.0	165.9	35.6	25.1	191.7
October	38.7	28.8	135.9	36.9	29.1	174.2	37.2	22.3	128.4
November	38.0	33.6	0.0	38.3	33.3	13.2	39.5	24.2	0.0
December	40.0	29.4	0.0	38.8	36.2	35.0	40.2	20.2	0.0
Annual			1317.5			1233.5			1011.7
Mean	37.4	22.2	109.8	37.4	29.9	102.8	37.9	23.1	84.8

Table 2: Soil chemical properties at the experimental site

Soil depth (cm)	Organic carbon (%)	pH_{H_2O}	pH_{CaCl_2}	Total N (%)	P available (ppm)	CEC (Meq/100 g)	Ca (Meq/100 g)	Mn (Meq/100 g)	K (Meq/100 g)	Na (Meq/100g)
0-15	1.40	6.8	6.1	0.08	27.33	2.0	1.12	0.03	0.17	0.09
15-30	0.49	6.2	5.9	0.06	21.28	1.1	0.37	0.02	0.14	0.06
30-60	0.72	6.2	6.0	0.07	20.63	0.7	0.15	0.04	0.08	1.00
60-100	0.24	5.9	5.7	0.05	23.10	0.5	0.08	0.01	0.07	0.08

Each experiment was set up in a randomized complete block design in three replications. The study was a single-factor experiment. The two woody legumes, *L. leucocephala* cv. 28 and *G. sepium* cv. ILG50 constituted the factor. The cultivars were selected on the basis that they were among the best performing cultivars in the subhumid tropics (IITA, 2000). Trees were spaced 4×0.5 m for a total of 3,727 trees per hectare. Each plot contains four rows of 20 trees per row for a total of 80 trees per plot. An alley of 4 m separates each plot.

The trees were raised directly from seeds. Seeds were collected from the International Institute for Tropical Agriculture (IITA), Ibadan, chemically scarified with 60% sulphuric acid before sowing. Four seeds were sown per hole at 4×0.5 m spacing in June 2000 and 2001. Two weeks after emergence, seedlings were thinned to one per hole based on the visual observation of vigour. Weed control was effected by hoeing at 3 weeks interval for the first 8 months after planting and thereafter slashing was done at a regular interval of 7 weeks. Dry season in the two years was relatively wet making manual irrigation unnecessary.

Dry matter, nodulation and nitrogen content determination: Eight plants were randomly selected and tagged from the two middle rows on each plot leaving the two outer rows as border for the determination dry matter accumulation, nodulation and nitrogen content. Dry matter accumulation, nodulation and nitrogen content were determined at 4, 8, 12 and 16 MAP. Two trees per plot were used per sampling date. For dry matter and nodule determination, 1.5 m and 45 cm radius trench was dug around each tree to ensure complete removal of root and nodules. The excavated root and nodule materials were washed with water to remove soil particles. Nodules were detached and counted per plant and recorded, fresh weights of nodules per plant were also taken. Nodules were later dried to a constant weight to determine nodules dry weight per plant. Nodulation index was calculated for each plant as nodule dry weight/shoot dry weight×100 (Hughes and Herridges, 1989). The whole plant was separated into root, stem and leaves and dried to a constant weight in a Gallenkamp oven at 80°C for 72 h. For the purpose of nitrogen content determination, about 5 g of tissue from nodules, stem root and leaves were ground separately in a Wiley micro hammer stainless steel mill. Nitrogen content of nodules, roots, stems and leaves were determined separately using the method described in the plant and soil analysis manual produced by the International Institute of Tropical Agriculture (1979).

Chlorophyll content and stability index determination: At two monthly intervals from 2-16 months after planting, chlorophyll content and chlorophyll stability index of the leaves of the two woody legumes were determined on five tagged plants per plot from the two middle rows. At sampling, fully expanded leaves were collected from the middle region of the canopy. Chlorophyll extraction was carried out according to the method of Witham *et al.* (1971). One gram of leaves per plant was homogenized in cold mortar with 5 mL of 80% acetone in a mortar. The mixture was centrifuged for 15 min. The clear supernatant was then made up to 20 mL with 80% acetone. The absorbance of the chlorophyll solution was read on a CL-34 visible spectrophotometer at wavelengths 664 and 647 nm. The amounts of chlorophyll 'a', chlorophyll 'b' and total chlorophyll in the extract were determined using the following equations as derived by Coombs *et al.* (1985).

$$\text{Chlorophyll a } (\mu\text{M/g tissue}) = 13.19\, A_{664} - 2.57 A_{647} \times V/1000 \times W$$

$$\text{Chlorophyll 'b' } (\mu\text{M/g tissue}) = 22.10\, A_{647} - 5.26\, A_{664} \times V/1000 \times W$$

$$\text{Total Chlorophyll } (\mu\text{M/g tissue}) = 7.93\, A_{664} + 19.53\, A_{647} \times V/1000 \times W$$

Where:

V	=	Final volume of chlorophyll solution
W	=	Weight of fresh leaves or bark
A_{664} and A_{647}	=	Absorbance at 664 nm and 647 nm wavelengths on a visible spectrophotometer, respectively.

For stem bark chlorophyll content determination, barks were collected at 5 cm above ground level on the main stem of the tagged trees. Extraction of chlorophyll and determination of chlorophyll content were determined as described above from 1 g of the stem barks.

Leaf chlorophyll stability index was determined as described by Sivasubramamiam (1992). Five grammes of fresh leaves were collected and divided into two lots, 2.5 g each. One lot was stored in room temperature and the other lot placed in empty test tube standing in boiling water bath for 1 h. Chlorophyll content of the two lots was extracted as described in (a) above. The absorbance of the extract was read on a visible spectrophotometer at 660 nm wavelength. Chlorophyll stability index was worked out according to the following equation:

$$\text{Chlorophyll stability index } (\%) = \frac{A_{660} \text{ of heated sample}}{A_{660} \text{ of unheated sample}} \times 100$$

Where, A_{660} = Absorbance value at 660 nm wavelength. Stem bark chlorophyll stability index was determined as leaf chlorophyll stability index above except that chlorophyll was extracted from one gram of bark collected at 5 cm above ground level on main stem.

Statistical analysis: Because primary interest was in comparison of species and variability was anticipated to change across sampling dates due to plant growth, separate analysis were performed for each sampling dates. Data on nodulation were presented graphically using Microsoft Excel Software. Analysis of variance was carried out on chlorophyll content and nitrogen yield data according to randomized complete block models. Least Significant Difference (LSD) was used to separate the means at 5% level of probability as outlined by Steel and Torrie (1998). The results of the two studies were separately analyzed and were not significantly different. Therefore, data collected for the trials were averaged and the means are presented.

RESULTS

Pre-planting soil chemical properties: The soil was very slightly acidic **($pH_{(H_2O)}$ 6.8)** . The total nitrogen (%), organic carbon (%), available phosphorus (ppm), cation exchange capacity (Meq/100 g), K (Meq/100 g), Mg (Meq/100 g), Ca (Meq/100 g) and Na Meq/100 g), of the 0-15 cm layer of soil were 0.08, 1.40, 27.33, 2.0, 0.17, 0.03, 1.12 and 0.09, respectively (Table 2).

Biomass accumulation and nodulation: There was a marked difference in dry matter production of the two species between 8 and 16 MAP (Fig. 1). The number of nodules produced by *G. sepium* (averaged 96.0/plant) was higher than in *L. leucocephala* (av.44.0/plant); there was a steady increase in number of nodules produced by *L. leucocephala* with age whereas in *G. sepium*, an upsurge occurred in nodule formation between 8 and

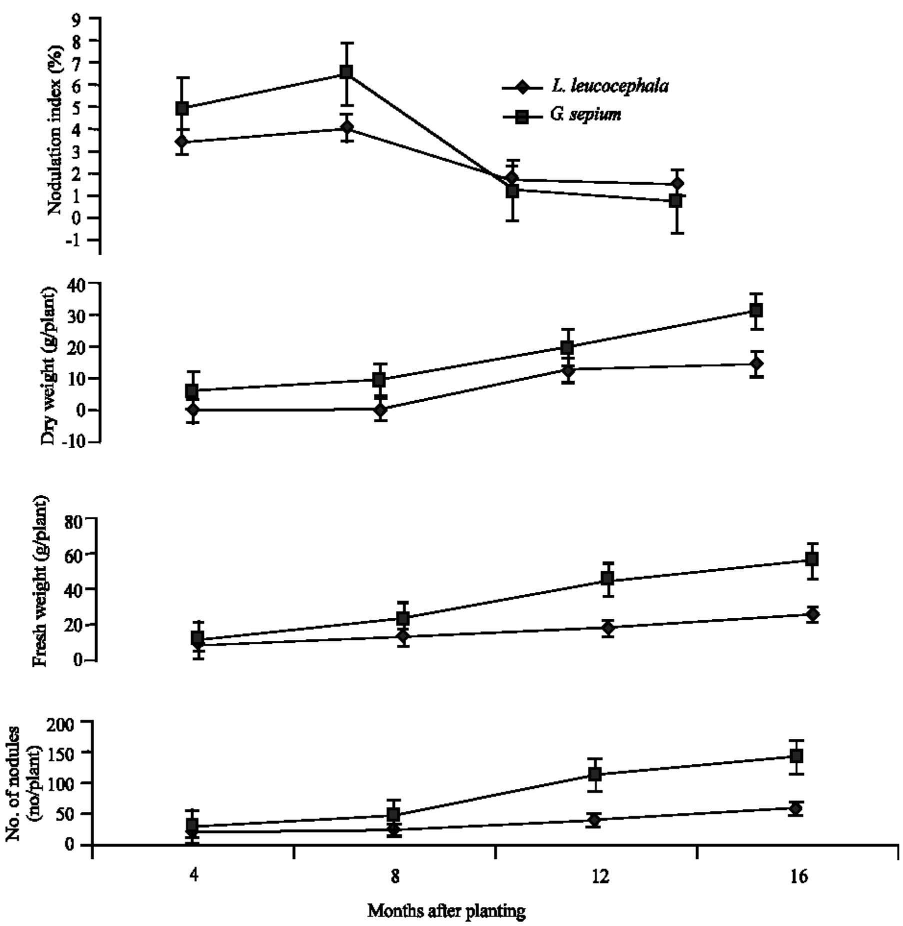

Fig. 1: Nodulation in *Lecaena leucocephala* (Lam) de Wit and *Gliricidia sepium* (Jacq) walp at different months after planting at Ile-Ife, Nigeria. Vertical bars represent standard error of the mean. Values are means of 2000 and 2001 studies

Table 3: Leaf chlorophyll content and stability index of *Leucaena leucocephala* (Lam) de Wit and *Gliricidia sepium* (Jacq) Walp at different months** after planting

		Months after planting							
Parameters	Hedge species	2	4	6	8	10	12	14	16
Chl. 'a' (µM/g)	*L. leucocephala*	1.50	1.70	2.00	2.20	2.90	3.00	2.80	1.70
	G. sepium	1.70	1.80	2.10	2.30	2.30	5.70	3.10	3.10
	LSD (0.05)	NS	NS	NS	NS	NS	0.25	NS	0.32
Chl. 'b' (µM/g)	*L. leucocephala*	0.50	0.60	0.80	0.90	1.20	1.20	1.30	0.80
	G. sepium	0.80	0.80	0.90	1.00	1.10	1.80	1.50	1.50
	LSD (0.05)	0.03	NS	NS	0.02	0.02	0.35	NS	0.41
Total chl. (µM/g)	*L. leucocephala*	2.00	2.30	2.80	3.10	4.10	4.30	4.10	2.60
	G. sepium	2.50	2.60	3.00	3.30	3.40	7.50	4.40	4.60
	LSD (0.05)	NS	NS	NS	NS	NS	0.31	NS	0.33
Chl. 'a'/'b' ratio	*L. leucocephala*	3.00	2.80	2.50	2.50	2.50	2.50	2.20	2.20
	G. sepium	2.20	2.30	2.30	2.30	2.30	2.80	2.10	2.00
	LSD (0.05)	1.00	0.01	0.01	0.02	0.04	0.03	0.03	0.04
Chl. stability index (%)	*L. leucocephala*	73.40	73.30	73.40	73.40	86.30	88.00	88.00	88.00
	G. sepium	64.30	64.60	65.10	65.30	65.30	80.60	81.30	81.30
	LSD (0.05)	5.32	5.34	4.51	4.39	5.01	4.11	4.91	5.13

NS- Not significant at 5% level of probability, Chl.- Chlorophyll, ** Values are mean of 2000 and 2001 studies

12 MAP. Fresh weight of nodules of *G. sepium* was higher than in *L. leucocephala* (av.41.30 vs 18.9 g/plant). Similarly, dry weight of *G. sepium* (av.18.5 g/plant) was greater than that of *L. leucocephala* (7.6 g/plant) throughout the period of study. Nodulation index of *G. sepium* (av. 5.5%) was higher than that of *L. leucocephala* (av. 3.7%) at 4 and 8 MAP. In both species nodulation index increased up to 8 MAP and declined thereafter (Fig. 1).

Chlorophyll content and stability index: The leaf total chlorophyll content in *G. sepium* ranged from 2.5 to 7.5 µM g^{-1} while that of *L. leucocephala* varied from 2.0 to 4.3 µM g^{-1}. The mean leaf total chlorophyll of *G. sepium* (av.6.1 µM g^{-1}) was significantly higher ($p<0.05$) than in *L. leucocephala* (av.3.3 µM g^{-1}) at 12 and 16 MAP (Table 3). The leaf chlorophyll content of *L. leucocephala* increased steadily up to 12 MAP and declined thereafter with an upsurge between 8 and 10 MAP. In contrast, in *G. sepium*, a steady increase in leaf chlorophyll content also occurred up to 12 MAP but an upsurge occurred between 10 and 12 MAP. Chlorophyll 'a' content in *G. sepium* (av.4.4 µM g^{-1}) was significantly ($p<0.05$) higher than in *L. leucocephala* (av.2.3 µM g^{-1}) at 12 and 16 MAP. Similarly, chlorophyll 'b' content of *G. sepium* was significantly higher than in *L. leucocephala* except at 4, 6 and 14 MAP. Chlorophyll 'a/b ratio decreased with age in *L. leucocephala* whereas it remained fairly the same in *G. sepium* except at 12 MAP. The chlorophyll stability index of *L. leucocephala* was significantly ($p<0.05$) higher than that of *G. sepium* throughout the duration of the study (av.94.5 vs 69.7%) (Table 3). In *L. leucocephala*, chlorophyll stability index remained the same up to 8 MAP, increased sharply between 8 and 10 MAP and remained the same thereafter. In comparison, chlorophyll stability index in *G. sepium* increased with age with a dramatic increase between 10 and 12 MAP. The stem bark chlorophyll content of *L. leucocephala* increased from 0.4 to 0.8 µM g^{-1} while that of *G. sepium* ranged from 0.6 to 1.9 µM g^{-1} (Table 4). Throughout the duration of the study, stem bark total chlorophyll content of *G. sepium* was significantly ($p<0.05$) higher than in *L. leucocephala* (Table 4). Unlike leaf chlorophyll content, the chlorophyll content of stem bark of both species increased slightly with age. Similarly chlorophyll 'a' and 'b' content of the stem bark of *G. sepium* was significantly ($p<0.05$) higher than in *L. leucocephala* throughout the duration of the study. Also, increase in chlorophyll 'a' and 'b' content of the stem bark in both species was less striking over ages. Chlorophyll stability index in *L. leucocephala* (92.7%) stem bark was significantly ($p< 0.05$) higher than that of *G. sepium* (69.8%) (Table 4). In *L. leucocephala*, the chlorophyll stability index increased gradually up to 8 MAP and remained constant thereafter whereas in *G. sepium* the chlorophyll stability index increased slightly with age.

Nitrogen accumulation and partitioning: The total nitrogen accumulated by *L. leucocephala* increased from 4.6 g/plant at 4 MAP to 42.8 g/plant at 16 MAP while that of *G. sepium* increased from 6.2 g/plant at 2 MAP to 54.2 g/plant at 16 MAP (Table 5). The total nitrogen content in *G. sepium* (54.20 kg/plant) was significantly ($p<0.05$) higher than in *L. leucocephala* (42.80 kg/plant) at 16 MAP (Table 5). The total nitrogen accumulation in both species increased with age with an upsurge between 8 and 12 MAP. The total nitrogen partitioned into nodules, roots, stems and leaves by *G. sepium* at every age was not significantly higher than in *L. leucocephala*

Table 4: Stem bark chlorophyll content and stability index of *Leucaena leucocephala* (Lam) de Wit and *Gliridia sepium* (Jacq) Walp at different months** after planting

		Months after planting							
Parameters	Hedge species	2	4	6	8	10	12	14	16
Chl. 'a' (μM/g)	*L. leucocephala*	0.30	0.30	0.30	0.40	0.40	0.60	0.60	0.60
	G. sepium	0.40	0.40	0.50	0.50	0.50	0.80	0.90	0.90
	LSD (0.05)	0.04	0.05	0.01	0.01	0.02	0.02	0.08	0.09
Chl. 'b' (μM/g)	*L. leucocephala*	0.10	0.10	0.10	0.20	0.20	0.20	0.20	0.30
	G. sepium	0.20	0.20	0.40	0.40	0.40	0.50	0.50	0.50
	LSD (0.05)	0.02	0.01	0.03	0.01	0.01	0.02	0.03	0.03
Total chl. (μM/g)	*L. leucocephala*	0.40	0.40	0.40	0.60	0.60	0.80	0.80	0.80
	G. sepium	0.60	0.60	0.90	1.30	0.90	1.30	1.40	1.40
	LSD (0.05)	0.11	0.20	0.35	0.28	0.18	0.25	0.20	0.21
Chl. 'a'/ 'b' ratio	*L. leucocephala*	3.00	3.00	3.00	2.00	2.00	3.00	3.00	3.00
	G. sepium	2.00	2.00	1.30	1.30	1.30	1.60	1.80	1.80
	LSD (0.05)	NS	NS	0.80	0.80	0.90	1.00	1.10	1.10
Chl. stability index (%)	*L. leucocephala*	90.50	92.70	94.50	94.60	99.80	99.80	99.80	99.80
	G. sepium	68.30	69.90	69.70	69.80	71.40	71.40	71.40	71.40
	LSD (0.05)	4.32	4.38	4.31	4.31	4.35	5.39	5.41	5.72

NS- Not significant of 5% level of probability, Chl.- Chlorophyll, ** Values are mean of 2000 and 2001 studies

Table 5: Nitrogen content of nodules, roots, stems and leaves of *Leucaena leucocephala* (Lam) de Wit and *Gliricidia sepium* (Jacq) Walp at different months** after planting

		Months after planting			
Parameters	Hedge species	4	8	12	16
Nodules (g/plant N)	*L. leucocephala*	0.1	0.1	0.3	0.9
	G. sepium	1.2	2.2	3.1	11.5
	LSD (0.05)	NS	0.08	1.12	1.23
Root (g/plant N)	*L. leucocephala*	2.4	12.3	16.3	14.2
	G. sepium	1.7	1.9	17.2	14.7
	LSD (0.05)	NS	NS	NS	NS
Stem (g/plant N)	*L. leucocephala*	0.3	1.3	9.9	14.9
	G. sepium	1.4	1.7	10.0	15.1
	LSD (0.05)	NS	NS	NS	NS
Leaf (g/plant N)	*L. leucocephala*	1.8	1.8	9.3	12.8
	G. sepium	1.9	2.0	9.6	12.9
	LSD (0.05)	NS	NS	NS	NS
Total (g/plant N)	*L. leucocephala*	4.6	15.5	35.8	42.8
	G. sepium	6.2	7.8	39.9	54.2
	LSD (0.05)	NS	NS	NS	3.37

NS- Not significant at 5% level of probability, ** Values are mean of 2000 and 2001 studies

except at 16 MAP for nodules. At final sampling (16 MAP), *G. sepium* partitioned 21.2, 27.1, 27.9 and 23.8% of its total nitrogen content to nodule, root, stem and leaf, respectively. In contrast, *L. leucocephala* partitioned 2.1, 33.2, 34.8 and 29.9% of its total nitrogen content into nodule, root, stem and leaf respectively. Both species partitioned the largest nitrogen content into the leaves at 4 and 8 MAP, roots at 12 MAP and stems at 16 MAP.

DISCUSSION

The formation of nodules in both species indicated their symbiotic association with native rhizobium since their seeds were not inoculated before planting. This confirms the findings of Mulongoy and Owoaje (1992) that *L. leucocephala* and *G. sepium* nodulate freely with native rhizobium. The higher number of nodules, fresh weight and dry weight of nodules and nodulation index of *G. sepium* than *L. leucocephala* have been reported by Ezenwa and Atta-Krah (1992) which they attributed to pattern of root development and lateral root formation. In addition, it is possible that the larger root biomass of *G. sepium* than *L. leucocephala* was responsible for the result. This is because large root biomass allowed exploration of soil for nutrients essential for nodule formation. Increase in dry matter accumulation with time was responsible for a decrease in nodulation index with time in both species. Increase in nodule formation with age in both species is a proof of suitability of the species for alley cropping as they are to remain for many years on the field. Similar report was made by Kadiata *et al.* (1995) on *L. leucocephala*.

Hereditary factor could account for higher chlorophyll content per unit fresh tissue of *G. sepium* than *L. leucocephala*. This implies that the capacity to convert light energy to assimilate will be higher in *G. sepium* than *L. leucocephala*. Though chlorophyll content of the two species were not compared in the literature yet Prasad and Rajeswar (1989) reported 2.8 mg g^{-1} as leaf chlorophyll content of *L. leucocephala* at 10 months of age. This value was lower than what obtained in this study (7.6 mg g^{-1}) possibly because it was a greenhouse experiment. The higher chlorophyll stability index of *L. leucocephala* than that of *G. sepium* implies that the assimilate production system of *L. leucocephala* may not be significantly disrupted by high temperature usually experienced in drought condition. This supports the findings of Awotoye *et al.* (1992) who reported large leaf area and biomass yield in *L. leucocephala* than *G. sepium* under drought.

Higher nodulation of *G. sepium* than *L. leucocephala* might be responsible for greater nitrogen content of *G. sepium* than *L. leucocephala*. This is similar to the findings of Mulongoy and Owoaje (1992). Result of this study also showed that nitrogen accumulation increased over time for both species. This ability to maintain an increasing nitrogen accumulation over one year indicates that the perennial nature of the species allows sustained nodulation and active nitrogen fixation up to the second year. This emphasizes the benefit of using tree legumes as soil nitrogen improvers rather than grain legumes which because of their short life span cannot make a sustained nitrogen contribution.

In conclusion, the higher values of number of nodules per plant, dry weight of nodules per plant, nodulation index, total chlorophyll of leaf and stem bark, nitrogen accumulation of *G. sepium* compared to *L. leucocephala* suggest that *G. sepium* is more productive as hedge species under no-external input field condition than *L. leucocephala*

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